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SELF-LIMITED AND UNLIMITED WORD USAGE DURING PROBLEM SOLVING IN--ETC(U)
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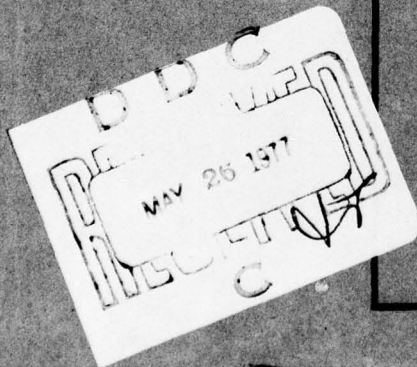
DEPARTMENT
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PSYCHOLOGY

TECHNICAL REPORT - 7

SELF-LIMITED AND UNLIMITED WORD
USAGE DURING PROBLEM SOLVING IN
TWO TELECOMMUNICATION MODES

APRIL, 1977

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handwriting or typewriting that there is no incentive to be concise in oral modes. Two-person teams of subjects solved problems cooperatively using either a voice or a teletypewriter mode of communication. Half the teams were given a monetary incentive to use as few words as possible. No such request was made of the control teams. The main finding was that subjects in the brevity condition, regardless of the communication mode, greatly reduced verbiage with no increase in time or decrease in accuracy. Moreover, subjects in the brevity-voice condition used even fewer words than did subjects in the control-teletypewriter condition. These results, then, lend weight to the second hypothesis.

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Self-limited and Unlimited Word Usage During Problem
Solving in Two Telecommunication Modes

By

W. Randolph Ford

A slightly modified version of this manuscript will be submitted for publication to a scientific journal. The manuscript is being distributed in this form to make the findings available sooner than they would be if we waited for publication and reprints.

The paper is based on a Master's essay completed by the author under the direction of Professor Alphonse Chapanis and Dr. Gerald D. Weeks. The research was supported in part by Contract Number N00014-75-C-0131 between the Engineering Psychology Programs, Office of Naval Research, and The Johns Hopkins University. Professor Alphonse Chapanis is the Principal Investigator for the contract.

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April 1977

Introduction

Research has shown repeatedly that cooperative problem solving is markedly affected by the communication channels available to the problem solvers (Chapanis, Ochsman, Parrish & Weeks, 1972; Chapanis & Overbey, 1974; Ochsman & Chapanis, 1974; Weeks, Kelly & Chapanis, 1974; Weeks & Chapanis, 1976). For example, teams of subjects solve problems about twice as fast when they communicate in an oral mode (e.g., by voice only or face-to-face) than when they communicate in a hard-copy mode (e.g., by teletypewriter or telepen). At the same time, teams using oral modes typically generate four to five times as many words as do teams using hard-copy modes. In these research studies the teams of subjects have, almost without exception, correctly solved their assigned problems. It seems clear, therefore, that no matter how they communicate, subjects manage to convey all the elements of information needed to solve these problems. That being the case, conversations in the oral modes must convey not only the information needed to solve problems, but a lot of supplementary information as well. Chapanis, Parrish, Ochsman and Weeks (1977) have estimated that in oral modes of communication, subjects use about 13 times as many words and 4 times as many unique words as are necessary.

One explanation for these differences between communication modes is that the hard-copy modes produce a record of all interchanges to which a person can refer at will. This record, or "hard copy," thereby reduces the need for subsequent requests for the same information. Voice communication, by contrast, is evanescent, and redundancy is necessary to compensate for the limitations of short-term memory.

Another possible explanation is that communication in the hard-copy modes is concise primarily because a greater amount of effort is required to communicate that way. On the other hand, voice communication requires so little effort that there is almost no incentive to be brief. If this latter explanation is correct, increasing the "cost" of word generation should result in subjects solving problems much more succinctly. How much more succinctly is impossible to predict from available data.

This study compared problem solving by teams of subjects who communicated either in a voice or teletypewriter mode. Half the teams in each mode were given strong monetary incentives to use as few words as possible, the other half worked with no such incentives. According to the findings of a study by Kelly and Chapanis (1977), teams of subjects who used restricted vocabularies assigned by the experimenter were able to solve problems just as quickly as teams using unrestricted vocabularies. Based on their finding I conjectured that teams given monetary incentives to be brief would be able to solve their problems just as fast as those without such incentives, and that the former would use far fewer words. Since teams using the voice mode characteristically use four to five times as many words as do those using the teletypewriter mode, I further hypothesized that a greater reduction in verbosity would occur in the voice mode than in the teletypewriter mode.

Method

Subjects

Sixty-four Johns Hopkins University undergraduates, 32 males and 32 females, were recruited for the experiment through posters advertising "an interesting experiment in telecommunication."

Experimental Facilities

The experiment was conducted in two sound-insulated rooms separated by an observation room. Each subject's room contained a worktable, chair and communication equipment for audio and teletypewriter channels. The subjects were provided with pencils, paper and the materials needed to solve their problem. The experimenter in the observation room could monitor both subjects through one-way mirrors.

Voice mode. In the voice mode, subjects communicated through a unidirectional microphone (SONY, Model #ECM-200S) and a loud-speaker (Lafayette, Model #99-45502) placed on the worktable in each subject's room. The output of each microphone was transmitted to the loudspeaker in the other subject's room and was simultaneously recorded on an individual track of a multi-channel audio tape recorder (SONY, Model #TC-353) located in the observation room.

Teletypewriter mode. In the teletypewriter mode, subjects communicated through two interconnected input-output writers (IBM Model #735). The teletypewriter mode, unlike the voice mode, was limited to half-duplex operation, i.e., messages flowed in only one direction at a time. A subject could take control of the circuit by pushing the key labeled "SEND" on the keyboard of his input-output writer. That action simultaneously released his own keyboard and locked his partner's keyboard. Control of the circuit was indicated by a small green light in a box over the input-output writer. A subject had control of the circuit until his partner depressed his own send key. In other words, the send key allowed each subject to interrupt his partner at any time. Messages

typed by a subject appeared on his own terminal in black but on his partner's in red, thus identifying the author of a particular message.

Problem Solving Tasks

The two problem solving tasks were cooperative in the sense that they required the efforts of two individuals working together as a team to reach a solution. Each member of a team received complementary information folios so that while neither person could solve the problem by himself, the two of them had all the information necessary to do so.

Faculty selection problem. One of the two subjects acted as a member of a student committee given the task of filling a vacant faculty position. A list of criteria was provided on which to base his decision. He was not allowed to relay these criteria to his partner, but was allowed to ask any questions he wanted about candidates. The other subject was given resumes of five hypothetical applicants from which he could provide information to his partner. The subject acting as the member of the student committee was to select the candidate that he felt best met the criteria. The problem was designed so that there was only one correct solution.

Object identification problem. This problem had been used before in similar communication studies (Chapanis & Overbey, 1974; Kelly & Chapanis, 1977; Weeks et al., 1974). Here one subject was given a small electric pilot light socket and was asked to obtain an identical replacement socket from the other subject. The latter had a tray containing 36 different Leecraft pilot light sockets. While all 36 sockets in his inventory were similar to one another, only one matched the target socket perfectly. The problem was completed when the subject with the tray was satisfied that he had selected the socket that matched the one described by his partner.

Although both problems were cooperative in nature, they differed in the cognitive demands placed on the subjects. In the faculty selection problem both team members had written materials to which they could refer, and from which they could compose messages or extract information to be relayed. In the object identification problem neither team member had any written materials; both subjects had to formulate their own messages. My conjecture was that communication could be affected by the presence or absence of printed information available to the subjects.

Word Usage

Two levels of word usage were tested in this experiment: self-limited and unlimited. Subjects in the self-limited condition were given a monetary incentive to use as few words as possible in the solution of the problem. They were told that in addition to what we normally think of

as words, utterances such as "uh," and "mm-hm" would count as words. Self-limited subjects in the teletypewriter mode were instructed that abbreviations such as "UCLA," or special symbols such as "#," would count as single words. Subjects in the unlimited condition worked with no word usage restrictions, and so served as a control group.

Experimental Design

The experiment (Table 1) had four completely crossed factors--communication mode, problem, word usage, and sex--with two levels of each factor, and with two teams in each treatment combination.

Table 1
Experimental Design

Communi- cation Modes	<u>Faculty Selection Problem</u>				<u>Object Identification Problem</u>			
	<u>Self-limited</u>		<u>Unlimited</u>		<u>Self-limited</u>		<u>Unlimited</u>	
	Male	Female	Male	Female	Male	Female	Male	Female
Voice	T ₁ ,T ₂	T ₃ ,T ₄	T ₅ ,T ₆	T ₇ ,T ₈	T ₉ ,T ₁₀	T ₁₁ ,T ₁₂	T ₁₃ ,T ₁₄	T ₁₅ ,T ₁₆
Teletype	T ₁₇ ,T ₁₈	T ₁₉ ,T ₂₀	T ₂₁ ,T ₂₂	T ₂₃ ,T ₂₄	T ₂₅ ,T ₂₆	T ₂₇ ,T ₂₈	T ₂₉ ,T ₃₀	T ₃₁ ,T ₃₂

Note: Each Team, T, consisted of two subjects.

Two models of the analysis of variance (Table 2) were used according to the measure being analyzed. Model A was used for all measures of team performance available in both communication modes. Model B was used for those dependent measures, simultaneous speech, silent time, and words per minute, that applied only to teams using the voice mode.

Procedure

Students who signed up for the experiment were contacted and haphazardly paired with another student of the same sex, forming 16 teams of like gender. At the same time, each subject on a team was arbitrarily assigned one of the two job roles. Each team was assigned at random, within the constraints of the experimental design, to one of the combinations of treatments.

Table 2
Analysis of Variance Models for the Various
Dependent Measures

Source of Variation	Degrees of Freedom	
	Model A	Model B
Word Usage (W)	1	1
Modes (M)	1	--
Problems (P)	1	1
Sex (S)	1	1
W X M	1	--
W X P	1	1
W X S	1	1
M X P	1	--
M X S	1	--
P X S	1	1
W X M X P	1	--
W X M X S	1	--
W X P X S	1	1
M X P X S	1	--
W X M X P X S	1	--
Between teams within treatment combina- tions	16	8
Total	31	15

When the two members of a team arrived for their session, they were introduced and remained together while the experimenter read their instructions to them. Subjects were told that the purpose of the experiment was to study the effects of certain restrictions on communication. Subjects in the teletypewriter mode were told that the typewritten records of their communication would be saved. Subjects in the voice mode were informed that their conversations would be tape-recorded. All subjects were told that the recordings would be treated as confidential research documents and would be used only to study the communication that transpired. Written permission was obtained from each subject to collect the relevant records.

Next, the experimenter explained the problem solving task and familiarized the subjects with the payment scheme. Subjects were told that they would each be paid \$2.00 if they finished the problem solving task plus another \$1.00 if they solved the problem correctly. An additional \$3.00 bonus would be allocated to each subject in the self-limited condition at the start of the experiment. At the end of the session the total number of words used by the team would be tallied and subtracted from the \$3.00 credit. In effect, these subjects were charged one cent for every word they used, not to exceed the original \$3.00. Subjects were told that they could use any method or strategy they felt would help them reach a solution to the problem.

After subjects had an opportunity to ask questions, they were escorted to their separate work places and familiarized with the communication channel and its proper operation. Problem related materials were not distributed until the experimenter was satisfied that subjects were proficient in the use of the communication channel.

During each session, the experimenter sat in the observation room to watch for any difficulties that might arise, to time the session, and, in the voice mode, to start and stop the tape recorder. The problem solving session was over when subjects felt they had reached a correct solution. After each session subjects were given a chance to ask questions or make comments about the experiment.

Data Collection and Analysis

Performance was assessed on two classes of dependent variables: time measures and verbal measures.

Time measures. The performance of the subjects was timed in two ways. Solution time was the elapsed time in minutes from the moment the experimenter said "begin" until a subject signalled the experimenter that the team had reached a solution.

Silent time, the number of minutes during a problem solving session when neither subject was talking, was measured for teams using the voice mode. The experimenter made this measurement with a stopwatch from the audio tape recordings, first clocking the number of minutes during which no communication occurred. As a check, he then measured the time during which communication did take place. The sum of these two measures should, of course, equal the total problem solution time. The sums were for some unknown reason uniformly shorter (from 1% to 8% shorter) than the solution times. Silent time was not determined for subjects in the teletypewriter mode because there were no suitable recordings from which to make such measurements.

Verbal measures. Both direct and derived verbal measures were obtained from the spoken and typewritten communications exchanged between team members. Subjects in the teletypewriter mode generated their own hard-copy protocols. Comparable protocols were transcribed from the audio tape recordings made during sessions in the voice mode. Insofar as practicable, these transcriptions preserved the subjects' natural style of communication and captured faithfully the complex verbal exchanges that took place. However, variations in pronunciation attributable to regional accent were ignored. Punctuation was added to the transcripts on the basis of context, word order, and intonation. Rules for making transcriptions were consistent with those generated in earlier work from the Hopkins laboratory (Chapanis et al., 1977).

(1) Words. The following liberal definitions of a word were used in counting the total number of words used by each subject:

1. Mispronounced words in the voice mode and misspelled words in the teletypewriter mode were counted as words.

2. Partial and incomplete words were counted as words. For example, "silv" for "silver" and "whi" for "which" were counted as words.

3. Colloquialisms and slang were counted as words. For example, "gotta" and "yeah" were each counted as single words.

4. Contractions, both standard and nonstandard, were counted as words. For example, "he's" and "what'd" were each counted as single words.

5. In the teletypewriter mode, combined numbers denoting a particular year, e.g., "1972," were counted as single words. In the voice mode, the same date was also counted as one word even though it was transcribed as "nineteen-seventy-two."

6. Interjections and vocal gestures, such as "hm" or "uh" were each counted as words on the grounds that they usually conveyed some

information. However, no attempt was made to distinguish between "uh" or "ah," "mm-hm" or "uh-huh," or between "hm" and "mm." Since such words were rarely articulated well, any attempt to transcribe distinctions among them would have involved a considerable amount of arbitrariness.

7. Special symbols in the teletypewriter mode were counted as one-character words. For example, "@," "*", and "+" were each counted as one word. When symbols were used to amplify or modify what immediately preceded them, i.e., "5%," the symbol was separated from the number and counted as a separate word. So, "5%" was counted as two words, "5" and "%."

8. Abbreviations and acronyms were counted as words. For example, "U" for university and "UCLA" for the University of California, Los Angeles, were each counted as single words.

9. Words run together or erroneously spaced in the teletypewriter mode were counted as their apparent constituent words. For example, "no-research" and "the re are" were each counted as two words.

Natural human communication is highly ungrammatical and unruly (Chapanis et al., 1977). Despite the rules above, counting words was an extremely difficult task. The counts reported here were made independently by two persons and all discrepancies between them were resolved in arriving at the final figures for data analysis.

(2) Messages. A message began when a subject started to talk or type and ended either when he had finished and relinquished control of the communication channel to his partner, or when he was interrupted. By this criterion, a message could vary from one word to an unlimited number of words.

In the voice mode, it was possible for both subjects to communicate at the same time. In fact, subjects could and did occasionally utter several messages during the course of a single message spoken by their partners. Occurrences of such overlapping messages, called "simultaneous speech" in this paper, were counted separately. Table 3 is a portion of an actual protocol containing two instances of simultaneous speech. Simultaneous speech was, of course, not possible in the teletypewriter mode.

(3) Message length. This measure was the total number of words used by a subject divided by the total number of messages he transmitted.

(4) Vocabulary. The vocabulary for each subject was the total number of unique or different words he used. Mispronounced, misspelled, partial, or incomplete words were counted as different words from their correct prototypes.

Table 3

Some of the Exchanges between Subjects who solved the
Faculty Selection Problem in the Voice Mode

A: Mm-hm

B; anyway uh, there's there's three references here one was uh, from
director of an oil company/

A: Mm-hm.

B; and uh, he was the one that was talking about uh, how effective he was
in uh associating with groups/

{A: Labor relations.

{B; and calming them

B; down.

{A: Mm-hm.

{B: Yeah.

B; And uh .. let me see. The other two were associates at Alaska U. and
uh .. uh, the second guy said, uh... talked about his ingenuity in
scientific sense/

A: Mm-hm.

B; so he probably uh... He seemed pretty impressed by him, uh also the,
the chairman of the department of psychology talked about how, uh, how
admired and revered he was by his students and his associates.

A: I see. Alright, uh...

B: I wonder why he was wanting to move?

Notes: A solidus (/) indicates that the speaker was interrupted at that point. A brace ({} in the margin encompasses those portions of speech that occurred simultaneously. A semi-colon after the speaker designation (e.g., A;) marks a continuation of a message. Two successive periods (..) indicates a short pause. Three successive periods (...) indicates that the speaker trailed off, not completing an intended message.

(5) Type-token ratio. The type-token ratio was the ratio of the number of vocabulary words, that is, the number of unique word "types," to the total number of words or "tokens" used by each subject.

(6) Percentage of simultaneous speech. This measure was the total number of words spoken simultaneously by both subjects of a team divided by the total number of words they used. Two examples of simultaneous speech appear in lines 5 and 6, and 8 and 9, of Table 3. If this were a complete protocol, the percentage of simultaneous speech would have been computed by dividing the 7 words spoken simultaneously by the 123 words in that table.

(7) Communication rate. Communication rate was the number of words used by a team divided by the total time it spent talking, that is, the time to solution minus the silent time. The total number of words used in this computation was first corrected by subtracting from it half the number of simultaneous words spoken by the team.

Results and Discussion

Every team arrived at a solution to its problem but only slightly more than half of the solutions (19 of 32) were correct. The correct solutions were, however, almost evenly divided between problems (9 versus 10), modes (8 versus 11), conditions (9 versus 10), and sexes (9 versus 10). Chi-squared tests show that none of these differences even approach significance. For these reasons, no further attention will be given to the correctness or incorrectness of solution.

The 26 statistically significant effects found in this study are given in Table 4.

Word Usage

There were 60 sources of variation, main effects and interactions, involving word usage in this study. Sixteen were statistically significant at $p \leq 0.05$. If we make the simplifying assumption that the dependent measures are mutually independent, such an outcome could have occurred by chance at $p = 3 \times 10^{-9}$.

Considered only as a main effect, word usage had a statistically significant effect on eight of the nine dependent variables. In fact, it is noteworthy that the only dependent variable not affected by word usage was time to solution. Moreover, the magnitudes of the differences between the self-limited and unlimited groups on the eight measures are impressive (see Table 5).

Silent time. In the unlimited condition about 18% of the total solution time was silent time, or conversely, 82% of the total solution time was spent in communication. For subjects in the self-limited condition, these percentages were almost exactly reversed (81% in noncommunicative activities; 19% in communication). Past research (Chapanis et al., 1972; Kelly & Chapanis, 1977; Ochsman & Chapanis, 1974; Parrish, 1974; Weeks et al., 1974; and Weeks & Chapanis, 1976) has shown that in tasks of this kind subjects spend about 30% to 75% of their time communicating, the

Table 4

Summary of all Statistically Significant Sources of Variance Found by the 9 Analyses of Variance

Sources of Variation	Time Measures					Verbal Measures					Dependent Variables	
	Time to Solution	Silent Time	Number of Messages	Number of words	Message Length	Vocabulary	Type-Token Ratio	% Simul. Speech	Communication Rate			
Word Usage (W)		.001	.050	.001	.010	.001	.001	.010	.050			
Modes (M)	.010	---	.050	.050		.050	.001	---	---			
Problems (P)						.050			.050			
Sex (S)		---		.050				---	---			
W X M						.050						
W X P												
W X S												
M X P		---		.050		.050	.050	---	---			
M X S		---						---	---			
P X S												
W X M X P		---		.050		.050		---	---			
W X M X S		---						---	---			
W X P X S	.010							---	---			
M X P X S		---						---	---			
W X M X P X S	.050	---				.050	.010	---	---			

Note: The p values are those of the upper limit of the intervals: $p < .001$; $.001 < p < .010$; $.010 < p < .050$.
 A dash (---) means that the term is not a source of variation in the analysis for the dependent variable.

proportion depending to a considerable extent on the communication mode and the problem being solved. It was anticipated that in solving the kinds of problems they were given in this study, subjects in the voice mode would spend a substantial proportion of their time communicating.

Table 5

Mean Values (per Subject) for the Dependent Measures that Differed
Significantly in the Two Word Usage Conditions

Dependent Measures	Word Usage	
	Self-limited	Unlimited
Percentage of silent time*	81.1	17.8
Number of words	72.3	460.5
Number of messages	13.3	41.8
Message length (words per message)	6.4	14.1
Vocabulary (number of unique words)	45.6	160.4
Type-token ratio	0.7	0.5
Percentage of simultaneous speech*	0.6	5.1
Communication rate*	119.8	160.4

Note: *For the voice mode only.

And so they did in the unlimited, or control, condition. What was not anticipated was the dramatic shift that occurred in the self-limited condition. Periods of silence of up to one minute were common, a situation that in normal conversation would be regarded as extremely awkward. However, the subjects appeared to accept and to adapt to these silences readily, in an impressive demonstration of the significant impact that incentive for brevity had on how subjects spent their time. Subjects could and did readily dispense with the conversational fillers (Duncan, 1972) that are used to provide continuity in normal conversation.

Number of words, messages, and message lengths. Teams in the self-limited group restricted their communication beyond my expectations, using, on the average, only $1/6$ as many words as did subjects in the unlimited condition. How did this decrease in the number of words affect verbal discourse? Did subjects communicate fewer messages, or did they transmit shorter messages? In fact, subjects did both. Self-limited subjects used only $1/3$ as many messages as their counterparts in the unlimited condition. Further, subjects in the self-limited condition shortened their messages to less than half, on the average. Tables 6 and 7 are typical protocols generated by two female teams, each of which correctly solved the object identification problem in the teletypewriter mode. The disparities between the numbers of words and messages used by the two teams are so striking that they need no further elaboration.

Unique words. Subjects in the self-limited condition used only $1/3$ as many unique words as did those in the unlimited condition. This is not surprising because the number of unique words, or size of vocabulary, is a function of the total number of words used (Horowitz & Newman, 1964). Since subjects in the self-limited condition used significantly fewer words than did those in the unlimited condition, we would expect the former to have smaller vocabularies. The relationship between the number of unique words and the total number of words is, however, not one of strict proportionality. The type-token ratio for subjects in the self-limited condition was significantly higher than that for subjects in the unlimited condition.

Simultaneous speech. The percentage of simultaneous speech in the self-limited condition was only about one-ninth that in the unlimited condition (see Table 5). One part of the explanation for this difference may be that subjects in the self-limited condition were more careful not to talk while their partners were talking, since to do so would have been wasteful of words and the subjects in this condition were being paid not to waste words. Nonetheless, it is interesting to note that the mean numbers of words per simultaneous interaction were almost identical (3.2 and 3.5 for subjects in the unlimited and self-limited conditions, respectively). Another part of the explanation for the difference may be that simultaneous speech is a function of both the number of words used and the silent time. Since subjects uttered fewer words and spent less time communicating in the self-limited condition, one should expect correspondingly fewer instances of simultaneous speech in that condition.

Communication rate. Subjects in the self-limited condition had a much lower rate of speech (see Table 5) than did the control subjects. The former tended to enunciate more clearly and to pause between words, instead of running words together, as is done in normal speech. This was apparently an additional precaution to insure that no words were wasted or that no message need be repeated.

Table 6

Complete Protocol for Two Female Subjects who Solved the Object
Identification Problem in the Self-limited Teletype Mode

A: less than inch long/high

B: all metal?

A: yes. silver cylindrical thing open at top-attached to rest at bttm.
to 1L.
L-shaped thing which curves at back to form wavy piece, sticking from
bttm of cylinder are two flat structures each with two holes in it.
structures separated by rubber-like disk

B: hole in L-shpaed part?

A: not exactly. between vertical part of L and wavy piece attached at
back.
disk at bttm sep by end of horixzontal part of L, then another disk.
argh

B: cylinder- cuts in it or

A: grooves
btt,m of whole has hole
??????

B: wavy L - side pieces?

A: no. one wavy picece on L at back, inside cylinder is copper disk
hinged to another f of same.

B: diameter of grooved cylinder?

A: 1/4 inch.

Note: On the original protocol Subject A's messages were in black type,
subject B's in red. The vertical spacing between messages and the hori-
zontal spacing have been adjusted here to make them more regular than on
the original.

Table 7

Protocol for Two Female Subjects Who Solved the Object
Identification Problem in the Unlimited Teletype Mode

A: it is round or

B: rr oval?

A: no, its more round

B: cylindrical?

A: ni sorry typing error let me finish the whole description ok

B: ok

A: it is round and has two little things/ sorry i mean i dont know what the things on it is ok

B: questrion; are there any wires coming out of it?

A: they R ARE NOT REALLY WIRES, BUT METAL EXTENSIONS WITH WHOLES ON THEM , TWO HOLES IN EA CH EXTENSION. AND TEEY ARE SEPARATED BY A CORK S substance dividing them and the round top has lines on it. and there is a clip like a money belt clip on the side of it. ok.?

B: antmmmanything else?

A: not really except the extensions are movableok?

B: can you give me a size? in inches or cm. or something?

A: the wholw the wholw the whole thing is about 1/2 inch big and it is about 1 inch wide-all of it. ok?

B: is it all the same color?

A: yes it is all the same color -a shint gray metal but the cork stuff which separates the extensions is brown. ok?

B: is there a little screw inside it?

A: yes, I guess you might call it a screw, it is copper on the top ok? I didn't really mean a screw, I meant a srping

B: spring

Table 7 (Continued)

-
- A: no it is definitely not a spring but it is also not a screw.
- B: ok when you say ths that it is about an inch wide, how ae are you looking at it?
- A: Well actually it could be considered an ince wide because the clip on the side is separated from the round teing with the extensions on it but all together the teing is wide by 1 inch. ok?
- B: do you think its significant that the extensions move?
- A: yes and it is also significant that they have two holes in each of teem
- B: ok just to make sure that I have picked out the right part, I'm going to describe it to you.
- A: good.
- B: it's a cylinder with lines on it which is attached to to little extensions each with two little holes in it this apparatus is attaches to a clip, with little cork or cardboard pieces separating the pieces.
- A: i have discovered that tee most important thing is that the cork must separate the two extensions if yours is to match mine and that the metal clip i'
- B: sorrry, continue
- A: the metal clip is in between the extensions and also the re are numbers on the back which might help teey say the thing is 75w and 125 v
- B: you're off the paper
- A: i mean 125 v ok?
- B: if yio if you hold it so that the round part is up, is the clip part up or down?
- A: the clip part is also up and it is no higeer tean tee cylinder ok?
- B: no higher ata all?
- A: just a little bit perhap
-

Table 7 (Concluded)

B: dor does it also say LEECRAF

A: yes

B: does the round part

A: the clip is about one cm higher than the round part. ok?

B: does the round part almost cover the c pat part of the clip that it is resting on or can you still see part of the metal base underneath it

A: lets start over uo you have the wrong thing al togeteer, the clip is separated form the rouu

B: I understand that what I want to know is if tee part of the clip that extends into the part where the extensions are separated by the cork is completely covered by the round part where they are closest together

A: no the clip and tee round part are spaced apart and neiteer piece covers anything.+

B: ok just one more w question. if you look at it from the top down, so that you are looking into the round part, can you see any of the cr cork?

A: yes the cork is visible but e there is that copper thing in the middle.

B: ok, I think we have it unless there is anything else from you

A: nope

B: ok

Note: On the original protocol Subject A's messages were in black type, subject B's in red. The vertical spacing between messages and the horizontal spacing have been adjusted here to make them more regular than on the original.

Time to solution. The data on silent time, or, conversely, on the time spent communicating, suggest that subjects in the self-limited condition took more time to compose and transmit succinct messages, and more time to decipher equally cryptic messages from their partners, than did subjects in the unlimited condition. One might, therefore, have expected a significant difference between the two groups in the time taken to solve problems. There wasn't. In fact, the mean time to solution for subjects in the self-limited condition was somewhat less, although not significantly less, than the corresponding mean time in the unlimited condition (14.9 versus 19.3 minutes). At least for the two problems studied here, solving problems with a parsimonious use of words required no more time, and may even have required less time, than problem solving under natural conditions of communication.

Modes

There were 14 statistically significant sources of variation, main effects and interactions, involving modes in this study. Assuming mutual independence among them, such an outcome could have occurred by chance at $p = 6 \times 10^{-8}$.

Teams using the teletypewriter mode took about twice as long to solve their problems as did those using the voice mode (Table 8). This

Table 8

Mean Values for the Dependent Measures that Differed
Significantly in the Two Communication Modes

	Modes	
	Voice	Teletype
Time to Solution (min.)	11.2	23.0
Number of Messages	42.1	12.9
Number of Words	384.7	148.2
Vocabulary (number of unique words)	122.9	83.2
Type-Token Ratio	0.4	0.7

finding is consistent with that of several experiments in which this comparison has been tested in the past (Chapanis et al., 1972; Chapanis &

Overbey, 1974; Ochsman & Chapanis, 1974; Weeks et al., 1974; and Weeks & Chapanis, 1976). That people can talk faster than they can type and so can solve problems faster when they can talk, is not itself particularly startling. What is much more impressive are the differences between the verbal outputs of subjects in these two modes.

Even though problems were solved faster in the voice mode than in the teletypewriter mode, subjects in the voice mode generated 3.7 times as many messages, 2.6 times as many words, and 1.5 times as many vocabulary words as did their counterparts in the teletypewriter mode. Subjects in the voice mode also had much lower type-token ratios than did those in the teletypewriter mode. All these findings replicate those of earlier work (Chapanis et al., 1977).

Message length was the only verbal measure that did not differ significantly between modes, another finding that is consistent with that reported by Chapanis et al. (1977).

Word Usage-Mode Interaction

Just as interesting as the main effects of word usage and modes is the interaction between them. Figure 1 shows that in the unlimited condition, subjects who communicated by voice used about three times as many words as did those who communicated by teletypewriter. In the self-limited condition, however, the difference between the voice and teletypewriter modes virtually disappeared. Indeed, subjects who communicated by voice used far fewer words than did the control subjects who communicated by teletypewriter.

Two possible hypotheses were advanced in the introduction to this paper to account for the very large difference one typically finds between the numbers of words used in voice and hard-copy modes of communication. One of these explanations is that redundancy is necessary in voice communication to compensate for the limitations of short-term memory and that the need for redundancy is reduced when one has a hard-copy to which he can refer. The findings in Figure 1 allow us to reject that explanation unequivocally. Although they are not definitive for any other alternatives, the data here are at least consistent with the hypothesis that voice communication is verbose primarily because it is so easy to communicate that way.

Sex

There were 60 sources of variation, main effects and interactions, involving sex in this study. Four were statistically significant at $p \leq 0.05$. If we make the simplifying assumption that the dependent measures are mutually independent, such an outcome could have occurred by chance at $p = 0.35$. Two sources of variation were significant at

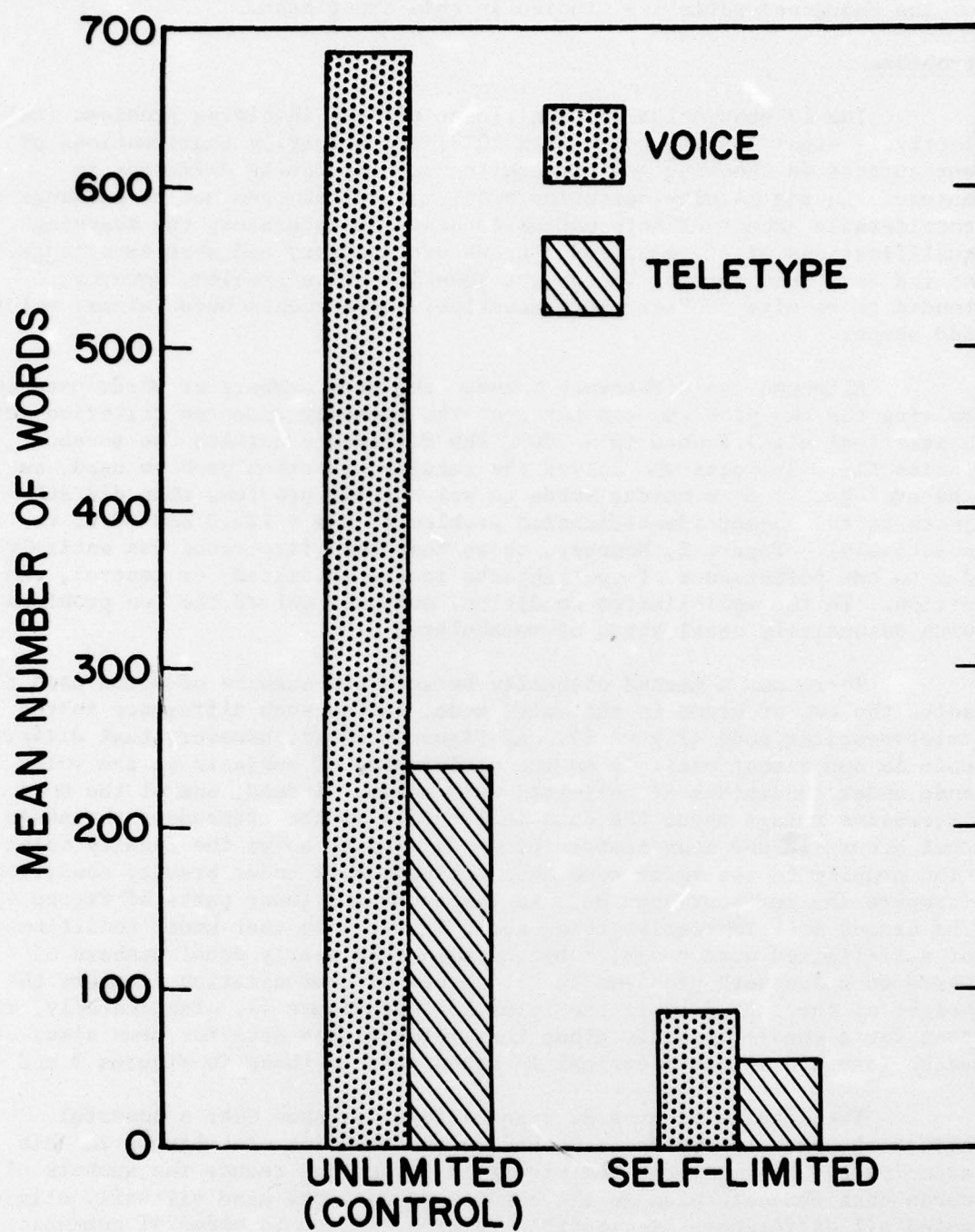


Figure 1. Mean numbers of words used by subjects in two telecommunication modes under two word usage conditions.

$p < 0.01$, an outcome that could have occurred by chance at $p = 0.12$. There is, therefore, no evidence that sex had a significant effect on any of the dependent variables studied in this experiment.

Problems

The 12 statistically significant effects involving problems (collectively significant at $p = 3.6 \times 10^{-5}$) are primarily confirmations of our success in choosing and structuring problems quite different in nature. In the faculty selection problem, the subjects had to exchange a considerable amount of information to describe accurately the teaching qualifications, i.e., education, areas of interest, and work experience, of the five candidates. The object identification problem, however, tended to require shorter, more descriptive statements about sizes, colors and shapes.

Although the difference between the mean numbers of words used in solving the two problems did not meet the commonly accepted criterion for statistical significance ($p = .06$), the difference between the vocabularies did. Subjects who solved the faculty selection problem used, on the average, 44 more unique words to solve their problems than did subjects in the object identification problem (Means = 125.3 and 80.8, respectively). Figure 2, however, shows that this difference was entirely due to the performance of the subjects in the unlimited, or control, condition. In the self-limited condition, subjects solved the two problems with essentially equal sizes of vocabulary.

There was a marked disparity between the numbers of words used to solve the two problems in the voice mode, but no such difference in the teletypewriter mode (Figure 3). As Figure 4 shows, however, that difference is due almost entirely to the performance of subjects in the voice mode under conditions of unlimited word usage. Indeed, one of the most impressive things about the data in Figure 4 is the tremendous shrinkage that occurs in the mean numbers of words used to solve the faculty selection problem in the voice mode when subjects work under brevity conditions (compare the leftmost open bars in the upper and lower parts of Figure 4). The second most impressive thing about Figure 4 is that under conditions of self-limited word usage, subjects used very nearly equal numbers of words to solve both problems in both modes of communication (compare the height of the four bars in the lower half of Figure 4). Incidentally, except for a change in scale along the ordinate, the data for mean sizes of vocabulary are almost identical in appearance to those in Figures 3 and 4.

The data in Figures 2, 3 and 4 together show what a powerful effect the brevity instructions had on the behavior of subjects in this experiment. Not only did the brevity instructions reduce the numbers of words that subjects used in all conditions but they also virtually eliminated all differences attributable to problems and to modes of communication.

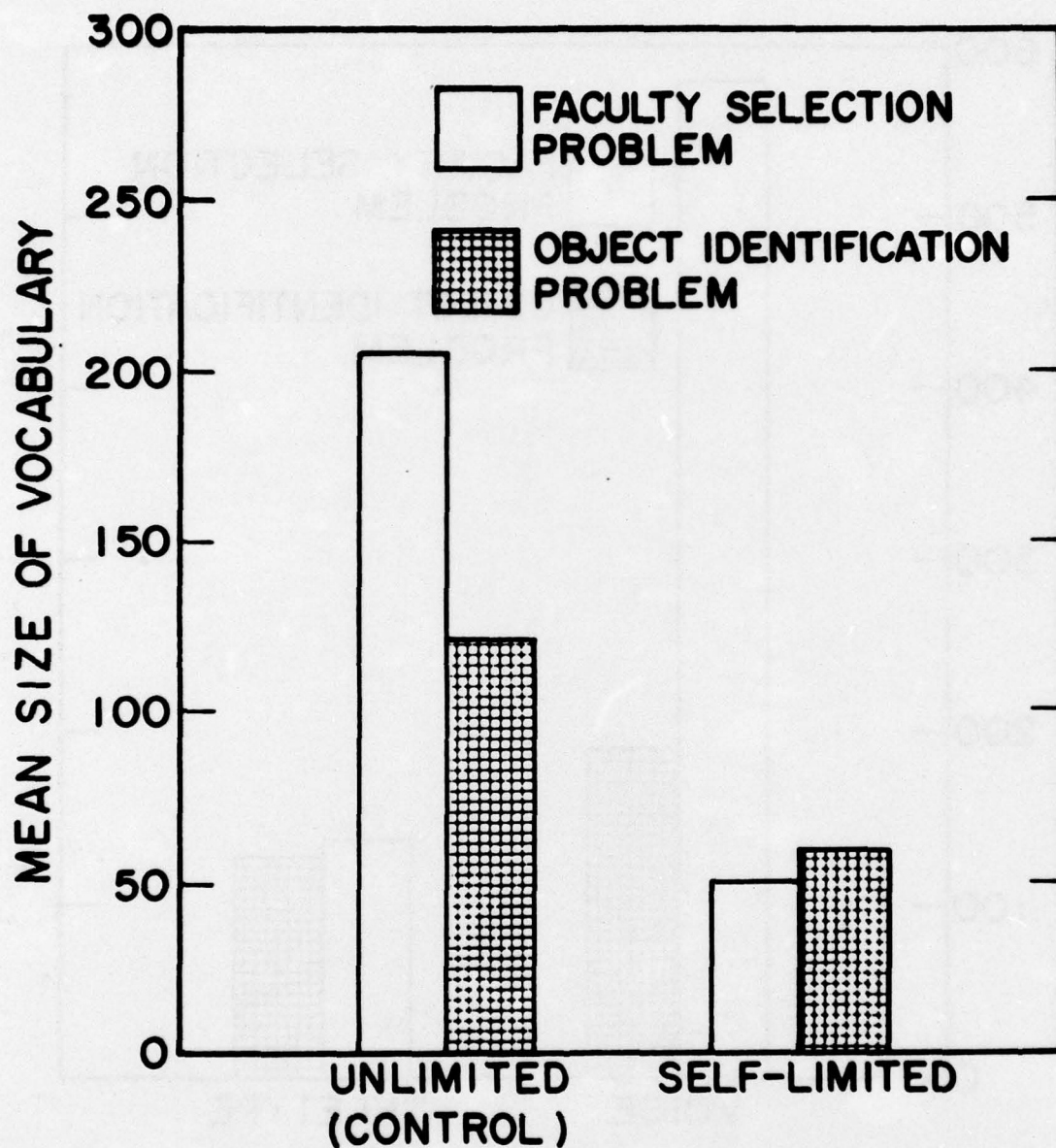


Figure 2. Mean sizes of vocabulary used by subjects who solved two problems under two word usage conditions.

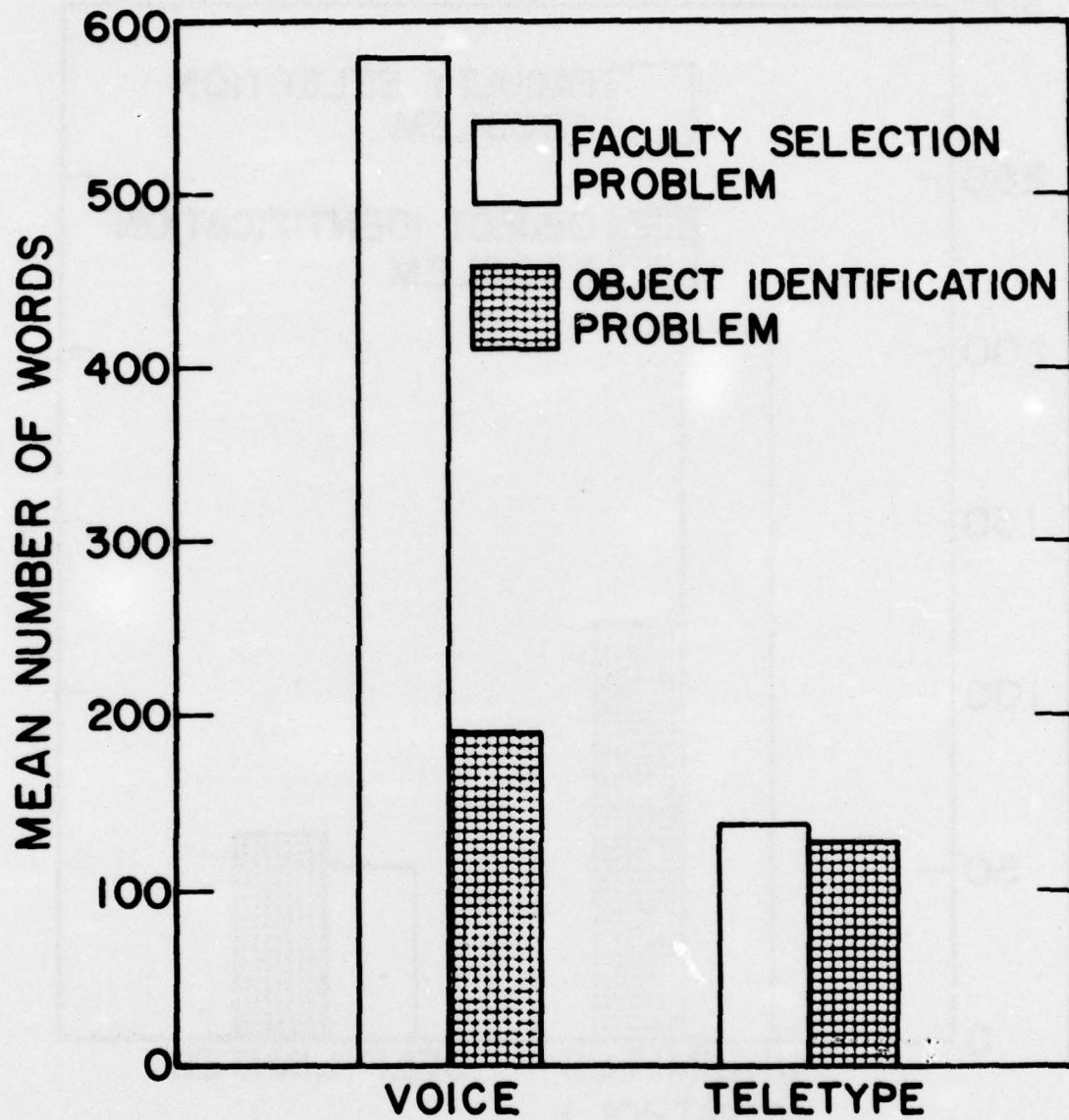


Figure 3. Mean numbers of words used by subjects who solved two problems in two telecommunication modes.

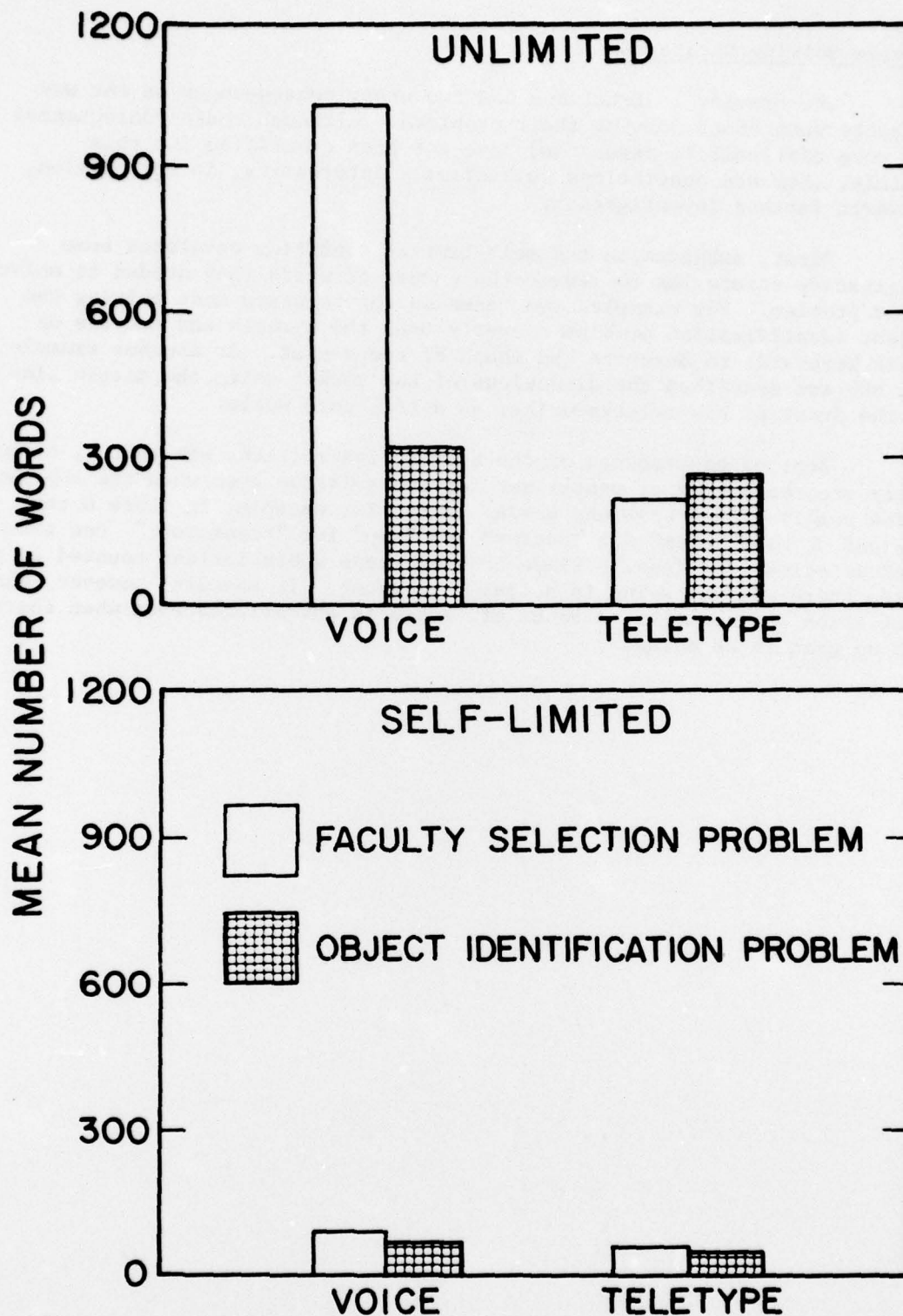


Figure 4. Mean numbers of words used by subjects who solved two problems in two telecommunication modes under two word usage conditions.

Problem Solving Strategies

The brevity instructions had two other consequences on the way subjects went about solving their problems. Although these consequences are more difficult to assess and have not been quantified for this article, they are nonetheless sufficiently interesting, in our opinion, to merit further investigation.

First, subjects in the self-limited condition developed some imaginative strategies to reduce the number of words they needed to solve their problem. For example, two teams in the teletype mode solving the object identification problem cleverly used the symbols and letters on their keyboards to describe the shape of the socket. As another example, one subject described the dimensions of the socket using the margin line on the front of his teletypewriter as a reference scale.

Another consequence of the brevity instructions was that it apparently created a kind of mental set for abbreviation even when the abbreviation really didn't save any words. Note, for example, in Table 6 that Subject A used "bttm" for "bottom" and "sep" for "separated." One team used asterisks for "yes." Since each of these abbreviations counted as a word, there was no saving in actual word count. It appears, however, that once given an incentive to be brief, subjects abbreviated even when there was no gain in so doing.

Conclusions

Given sufficient incentive to be brief but without any specific instructions on how to do so, people solve factual problems with far fewer words, fewer messages, and shorter messages than they would normally use.

That people can be more concise than they are ordinarily is not in itself a surprising finding. What is interesting is how much more concise they can be. Subjects who worked under the brevity instructions used about one-eighth as many words as did controls in the voice mode of communication, and about one-quarter as many words in the teletypewriter mode. Since subjects normally use far fewer words in the teletypewriter mode than in the voice mode of communication, the latter finding is especially interesting. Indeed, subjects who worked with the brevity instructions in the voice mode used only about one-third as many words as did control subjects in the teletypewriter mode. Moreover, there was no significant difference between the numbers of words used in the voice and teletypewriter modes by subjects who worked with the brevity instructions.

Collectively, these findings suggest that voice communication is normally very much wordier than hard-copy modes of communication not so much because of the limitations of short-term memory, or the presence or absence of a hard-copy to which one can refer, but rather because of the relative ease of communication in the two different modes. It is very much easier to talk than to type and, if there is no incentive to be brief, people will talk.

Concise communication is no more time-consuming than normal communication. Problems were solved about equally fast by subjects who worked under the self-limited condition as by those in the unlimited condition. Communications by the former were, however, characterized by a very high proportion of silent time--pauses that in normal conversation would be regarded as awkward--and by much higher type-token ratios than in the unlimited condition.

Differences between the voice and teletypewriter modes of communication normally found in tasks of this kind also appeared in this study.

In general, the major findings of this study are robust and hold for both sexes, both kinds of problems, and for the interaction between them.

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